



Traffic Flow Management in CAASD's System-Wide Model

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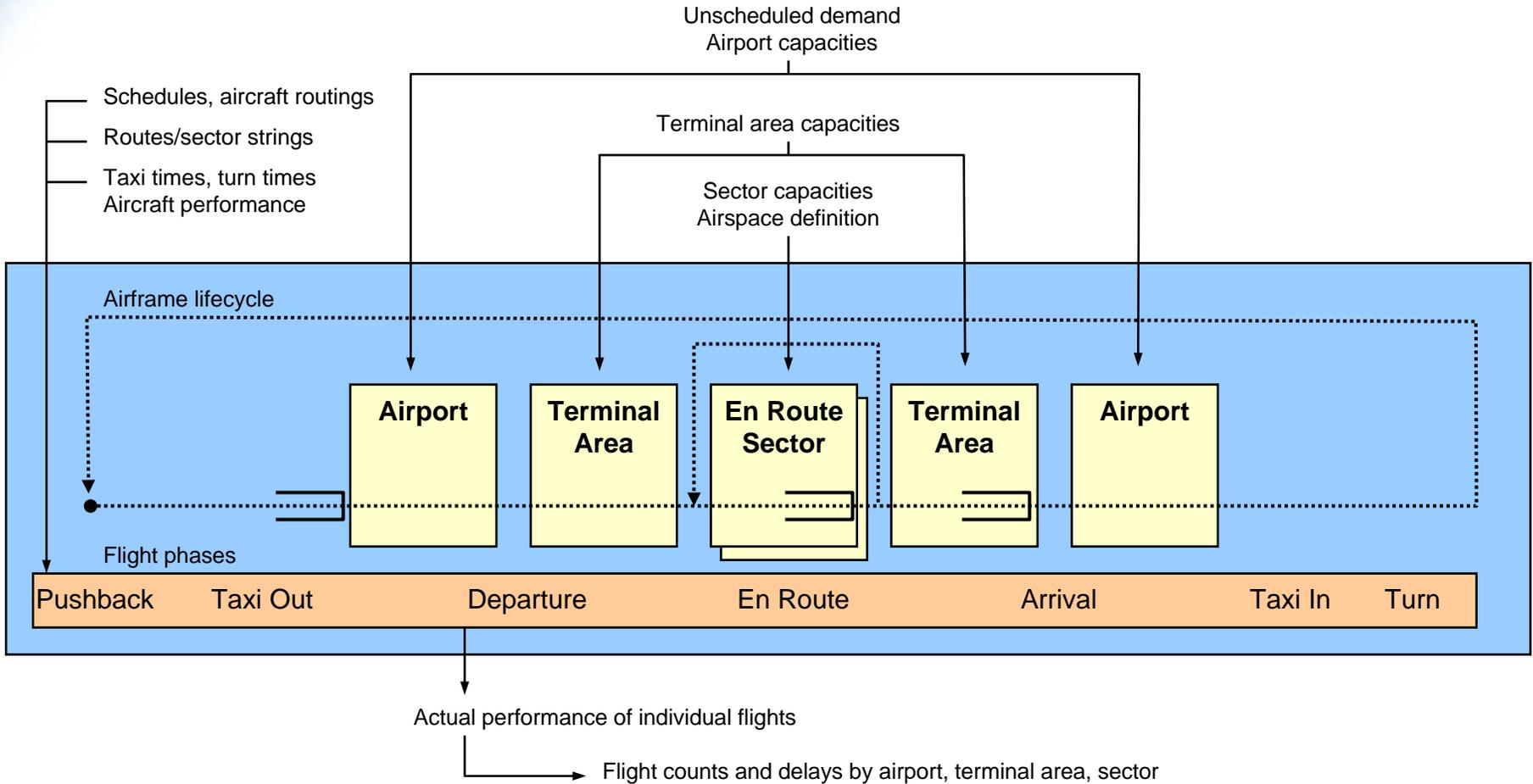


CAASD System-Wide Modeling

- **CAASD system-wide analyses performed in support of various decision-making activities**
 - Cost and benefits assessment
 - Alternatives analysis
 - Design
- **Objectives are to answer questions and provide insight about**
 - Impacts on
 - Traffic loads (airport, arrival/departure queues), sectors, airways
 - Delays (schedule and technical)
 - Controller workload
 - Fuel burn
 - Due to changes in
 - Demand (commercial schedules, general aviation activity)
 - Capacities (airports, en route sectors)
 - Procedures and operational strategies (TFM initiatives)
- **The model enables many such analyses**
 - NAS-wide simulation of moderate fidelity
 - Populated with standard data sources (e.g., ACES, OAG, ETMS) and output of higher fidelity CAASD models (e.g., EACM)
 - Run-time is minutes to hours depending on trajectory model and features turned on



Model Overview





Trajectory Model Alternatives

- **String of sectors**
 - En route sectors explicitly identified
 - Transit times provided
- **Idealized trajectory**
 - Flies route waypoints
 - Flies idealized altitude and speed profile
 - Depends on equipment type
 - Base of Aircraft Data (BADA) parameters
- **Collaborative Routing Coordination Tools (CRCT) trajectory model**
 - Respects altitude restrictions



Current TFM Features

- **Explicit model of specified TFM initiatives**
 - **Ground stops**
 - **Ground delay programs (GDP)**
 - **Miles/minutes-in-trail (MIT) restrictions**
- **Initiatives are activated according to input schedule**
 - **Cancellation times may be provided as well**
- **Compliance modeled as probability flight respects restrictions**



TFM: Ground Stops

- **Suspends departures to target airport from specified airports until end time**
- **Model**
 - **When simulation reaches ground stop announcement**
 - **Qualifying departures reschedule pushback for ground stop end-time**
 - **Flights respect ground stop with probability consistent with compliance rate**
 - **When simulation reaches cancellation (if any)**
 - **Qualifying departures reschedule for immediate pushback**



TFM: Ground Delay Programs

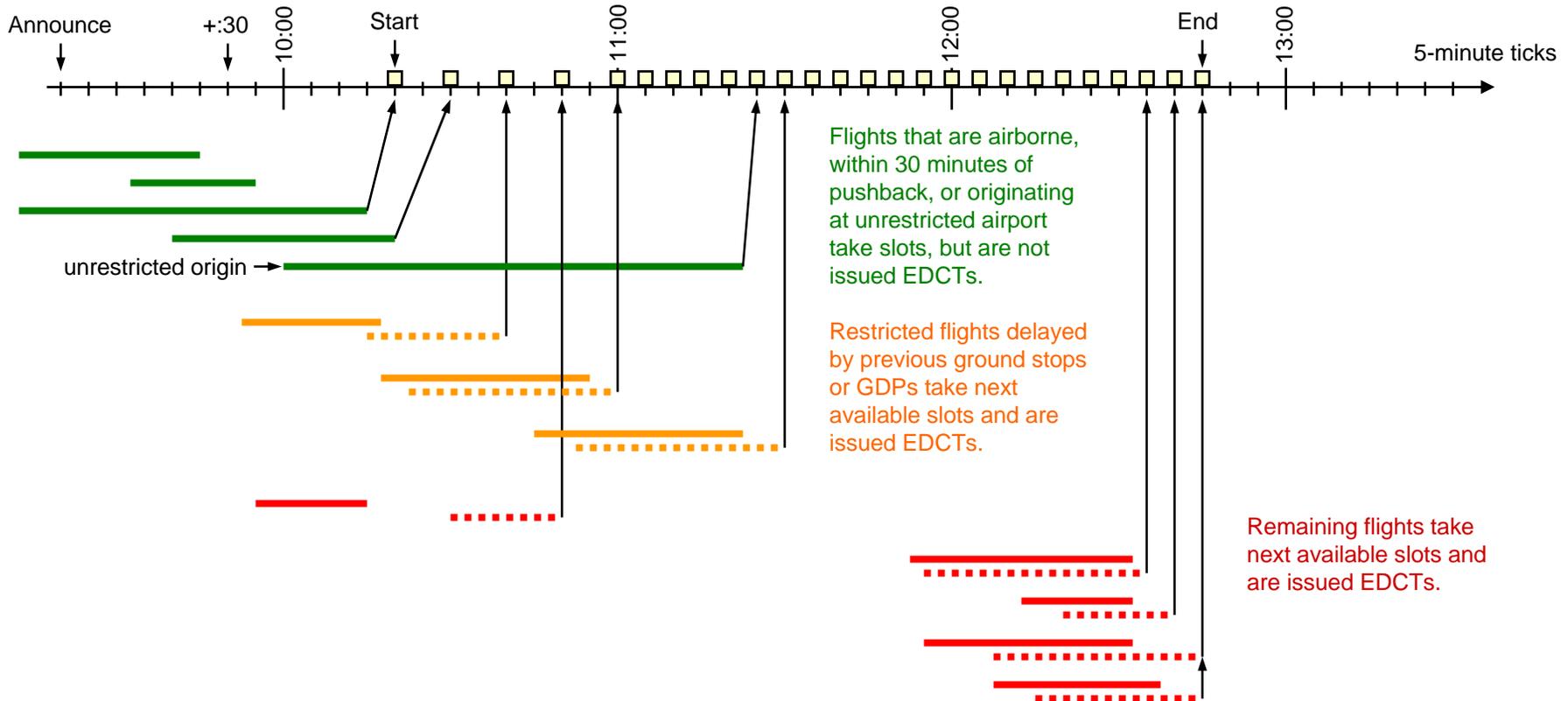
- **EDCTs issued to flights bound for target destination from specified origins to achieve specified arrival rate by hour**
- **Model**
 - **When simulation reaches GDP announcement**
 - **Arrival slots determined for each hour that GDP effective**
 - **Evenly distributed over hour**
 - **Available slots assigned to flights, first by following categories, then by scheduled arrival time**
 - **Airborne flights, flights within 30 minutes of scheduled pushback, flights not departing restricted origin**
 - **Restricted flights subject to previous ground stops or GDPs**
 - **Other restricted flights**
 - **EDCTs issued to second and third groups consistent with slot assigned (and planned trajectory)**
 - **If no slot assigned, EDCT consistent with arrival at GDP end time**
 - **Flights respect EDCTs with probability consistent with compliance rate**
 - **When simulation reaches GDP cancellation (if any)**
 - **Delayed flights free to depart**



TFM: Ground Delay Program Example

Announced at 9:20
Start at 10:20, End at 12:45
Rate is 6 for 10:00-11:00
Rate is 12 for 11:00-13:00

Slots evenly distributed over clock hours consistent with target rates





TFM: MIT Restrictions

- **Minimum spacing or time restrictions placed on consecutive sector boundary crossings**
- **Model**
 - **Flights occupy “restriction resource” upon entering downstream sector**
 - **Duration of occupancy is MIT time (or time to fly MIT spacing at crossing speed)**
 - **Maximum occupancy is one**
 - **Flights continue to occupy upstream sector while queuing for restriction resource**



Ideas for Future TFM Enhancements

- **Improvements to current features**
 - Triggering of initiatives in response to simulated conditions
- **Endogenous route selection**
 - Playbook and other route advisories
 - Selection from library rather than dynamic route planning
- **Strategic traffic management**
 - Current resource/queuing model is very tactical
 - Exploring request-grant-accept model for planning
 - Flights *request* permission to use downstream resources
 - Possibly shopping for best offers
 - Layers of resource managers *grant* permission for earliest acceptable time
 - Seek to maintain feasible conditions
 - » Wide scope, crude conditions for far downstream
 - » Narrow scope, detailed conditions for immediate
 - Obligated to respect accepted grants
 - Flights *accept* best offer and are free to progress accordingly



Acronyms

ACES	Adaptation Controlled Environment System
BADA	Base of Aircraft Data
CAASD	The MITRE Corporation's Center for Advanced Aviation System Development
CRCT	Collaborative Routing Coordination Tools
EACM	Enhanced Airfield Capacity Model
EDCT	Estimated Departure Clearance Time
ETMS	Enhanced Traffic Management System
GDP	Ground Delay Program
MIT	Miles/minutes in-trail
NAS	National Airspace System
OAG	Official Airline Guide
TFM	Traffic Flow Management